SCIENTIFIC NOTE

Fleas Occurring on Mice During the Mouse Population Explosion in the Western Side of Leeward Oahu, Hawaii

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Abstract: A survey of fleas on mice during the mouse population explosion that occurred in eight communities in the western side of leeward Oahu was carried out in the summer of 2006. A total of 1440 mice were obtained. 305 oriental rat fleas, *Xenopsylla cheopis* (Rothschild) were recovered from these mice. No significant difference existed for the flea infestation rates, the average number of fleas per mouse (the flea index) and the average number of fleas per infested mouse among the communities. Overall, the flea indexes appeared high, indicating that a large number of fleas would be produced during an increase in mouse populations.

Key words: *Mus musculus*, *Xenopsylla cheopis*, Hawaii

Introduction

The fleas of rodents serve as very important vectors of disease pathogens, such as plague, etc. Surveys of fleas on rodents have been carried out in different parts of Hawaii in the past (Eskey 1934; Mitchell 1964a; Haas 1965; Hass et al. 1972; Radovsky et al. 1979; Tenorio and Goff 1980). However, little is known of their occurrences when there is a mouse (*Mus musculus* L.) population explosion. In the leeward areas of the Hawaiian Islands, mouse population explosions occasionally occur during periods of drought in the summer. When food supplies dry up, the mice migrate to nearby communities seeking food and water (Hawaii Department of Health, Vector Control Branch, unpublished).

Mus musculus is considered to be a reservoir for murine typhus; and fleas such as *Xenopycella cheopis,* among other species, are considered to be the vectors of murine typhus (Traub et al. 1978). During the mouse population explosion, the flea number may increase and enhance the probability of contact with humans and domestic animals. During the summer of 2006, Hawaii Department of Health, Vector Control Branch personnel conducted mouse population surveys in the western part of the leeward areas of Oahu for mice control. At the same time, fleas on mice were collected, identified and counted. This study presents the result of that flea survey.

Materials and methods

Eight communities in the leeward side of Oahu including Nanakuli, Maili, Waianae, Makaha, Makakilo, Royal Kunia, Kapolei, and Ewa Beach were chosen for the flea survey. Nanakuli, Maili, Waianae and Makaha are adjacent to each other and located in the valleys at the most western end of the leeward side; Makakilo is located on a slope of the Waianae Range; and Royal Kunia, Kapolei and Ewa Beach are located on the coastal plain.

From June to September 2006, mouse populations in the western part of the leeward areas

of Oahu were surveyed using tin-cat mouse traps (RePeater@ Mouse trap, Twinsburg, OH) baited with dog food. Based on the size of communities, different number of samples was taken. For each sample, thirty five tin-cat mouse traps were set up at 5 sites with 7 traps each. The traps were set up in the morning and collected and brought back to the laboratory on the following morning. The mice with the trap were put in a plastic bag and killed using CO_2. Then the mice were sprayed with Sumithrin and fleas on the mice were combed and collected. The fleas were identified and counted under a dissecting microscope using a key to "The ectoparasites of Hawaiian rodents" provided by Tenorio and Goff (1980). Voucher specimens were deposited in the Hawaii Department of Health, Vector Control Branch collection facility, located in Halawa Valley, Oahu, Hawaii.

The percentage of mice infested by fleas and the average number of fleas per mouse (also per infested mouse) were calculated for each community. The average number of fleas per mouse is usually defined as "the flea index." All comparisons of mean values among different communities were examined using one-way ANOVA and the data were transformed by square root for the flea numbers and by the arcsine method for the infected rates of flea on mice (Analytical Software 1996).

Results

A total of 1440 mice were obtained from the surveys in the western part of the leeward communities of Oahu. From these mice, 305 Oriental rat fleas, *Xenopsylla cheopis* (Rothschild) were recovered (Table 1). The highest flea infestation rate of mice was from Maili (0.17), while the lowest was from Ewa Beach (0.05). But, overall, no significant difference existed in flea infestation rates among the communities ($F=0.60$; $df=7, 41$; $p=0.749$). The highest number of fleas per mouse and per *flea-infested* mouse both occurred in Nanakuli (0.28 and 2.09), while the lowest number occurred in Ewa Beach (0.05 and 1) (Table 1). There are no statistically significant difference among the communities in the average number of fleas per mouse ($F=1.19$; $df=7, 41$; $p=0.33$), nor in the average number of fleas per infested mouse ($F=0.4$; $df=7,35$; $p=0.894$).

Discussion

Mouse population *explosions* are natural phenomena that occur in Hawaii and other places. However, it seems that there is no a standard definition of an "explosion." In this survey we defined the occurrence of a mouse population explosion based on the high trapping number, occurrence of mice burrows in open areas, mice foraging activity during the day, and a high number of mice complaints from residents.

Only one species of flea, *X. cheopis,* from *M. musculus* was recovered from this survey. This was also the only flea species reported infesting *M. musculus* on the island of Kahoolawe (Hass et al. (1972) and on Manana, an islet lying off the southeast shore of Oahu, Hawaii (Hass 1965).

No previous data on the fleas found on mice exist in these communities for comparison. However, some studies do provide an indication of what is considered normal. Eskey (1934) reported that the average flea index of mice during an entire year survey was 0.13 for the island of Oahu, 0.08 for the island of Maui, 0.08 for Hilo (on the big island) and 0.05 for Hamakua district (on the big island). These flea indexes are obviously lower than those found in the present survey. Kartman and Lonergan (1955) reported that the mean number of fleas was 0.20 per rat (*Rattus rattus*), and 1 or 2 per flea-infested rats in rural areas of an enzootic plague region in Hawaii. Hass (1965) indicated that the number of *X. cheopis* was low on mice compared to other rodents such as *Rattus norvegicus* and *R. rattus* because

Table 1. *Xenopsylla cheopis* on *Mus musculus* in western leeward communities of Oahu, Hawaii.

Location	Total mice	Mice with fleas	Positive rate	Total fleas	Mean (±SE) per Mouse	Mean (±SE) per Infested mouse
Nanakuli	392	53	0.14	111	0.28 (0.11)	2.09 (0.82)
Maili	153	26	0.17	38	0.25 (0.04)	1.46 (0.19)
Waianae	199	29	0.15	37	0.19 (0.08)	1.28 (0.55)
Makaha	117	19	0.16	30	0.26 (0.11)	1.58 (0.25)
Makakilo	277	31	0.11	38	0.14 (0.04)	1.23 (0.23)
Kapolei	119	11	0.09	19	0.16 (0.1)	1.73 (0.59)
Ewa Beach	63	3	0.05	3	0.05 (0.02)	1.00 (0.25)
Royal Kunia	120	16	0.13	29	0.24 (0.13)	1.81 (0.09)
All locations	1440	188	0.13	305	0.20 (0.03)	1.52 (0.12)

M. musculus have blood that is physiologically deficient in nutrients needed for high fertility in *X. cheopis*. However, in this survey the overall average number of fleas was 0.20 per mouse and 1.52 per-flea infested mouse, respectively, which are almost equal to the values reported for rats by Kartman and Lonergan (1955). Therefore, we can conclude that the flea index in this survey is quite high. Furthermore, a large number of mice can clearly carry a large numbers of fleas when the flea index is high.

Historical records show that there are more murine typhus cases in leeward areas than windward areas of the Hawaiian Islands (Manea et al. 2001). Many studies have shown that seasonal occurrences of *X. cheopis* correlated well with incidences of murine typhus in most areas (Dyer et al. 1931; Dyer 1942; Eskey and Hemphill 1948; Mohr 1951; Smith 1957). We believe that the house mouse population explosion and the resulting increase in numbers of *X. cheopis* play an important role in the disease transmission in the leeward areas of the Hawaiian Islands.

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